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Variation in the floral structures of Vitis*

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(WITH PLATES 1–3)

The genus *Vitis* has invited special attention botanically and horticulturally on account of its economic importance. The normal morphology of the flower is, of course, well known, and some observations have been made respecting variation in the different floral members. It would seem, however, that there is accessible no sufficient account of variation in the floral types. In the present paper the writer proposes to bring together some general facts and observations and especially to record some studies on the structural and numerical variation in the floral parts of certain species and varieties.

GENERAL FLORAL HABITS OF VITIS

The flower of *Vitis* presents a number of interesting variations, occurring both in the number and in the development of floral parts. In the flowers of many other genera where there is a multiplication of floral envelopes, there is often a complete or partial metamorphosis of some of the members into others, as in doubling, where stamens may be found showing a more or less complete transformation into petals. In *Vitis*, however, there occur either only completely developed floral members, or if there are modifications, they are in the direction of the suppression of certain members. There is, moreover, a close numerical relation

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between members of the floral organs in the several whorls; and this relation obtains when there occurs either an increase or decrease in the number of parts of the flower.

FLOWER TYPES: *Vitis* may be regarded as dioecious, polygamo-dioecious, or perfect. Individual vines of *V. vulpina* and *V. bicolor* occur in the wild in either the staminate or the perfect form. By staminate is meant forms in which no well-developed pistils are produced.

In the open the staminate plants occur in the greater number; of the 347 vines observed by the writer, 218 were staminate and 129 perfect. In these species the reflexed or recurved type of stamen was an invariable accompaniment of the perfect flower; that is, in no case were upright stamens found along with well-developed stigmas. Two wild vines, however, of *V. vulpina* were found in which the stigmas were partially developed. Yet the upright stamen form is to be regarded as signalizing the typical perfect flower, since, as is shown later, pollen development in the reflexed stamen may be poor.

As has been observed by Engelmann ('94) and others, the cultivated varieties, on the other hand, have two distinct floral types which are quite constant for all of the individual vines of a variety. These types are both perfect forms, the one possessing upright and the other reflexed or recurved stamens. As might be expected, the staminate form is not found under cultivation, except in rare instances where it may be grown in order to pollinate some of the self-sterile varieties.

It may be of interest to consider briefly the significance of the perfect form of flower, in general. From the standpoint of the evolution of the floral forms, either we may regard the perfect flower as the original form, and the pistillate and staminate forms as being derived from this; or we may consider the original form to have had diclinous flowers, and the perfect form to have been a later development.

There occur in the known species of *Vitis*, flowers (1) with stamens upright and pistils abortive (functionally staminate), (2) stamens upright and pistil fully developed and functional (perfect), and (3) stamens reflexed, pollen more or less abortive, and fully developed pistils (sometimes functionally pistillate).

Flowers possessing no stamens do not occur, or at least have not been recorded. Among these existent floral types which way is the evolution taking place? Goebel ('98) states "as a further peculiarity of the angiospermous flower that it is predominantly hermaphrodite, and unisexual flowers can be proved to be frequently the result of arrest of either the microsporophylls or the megasporophylls."

The perfect form of flower occurs in the cultivated varieties of many species of grape. In fact, this form of flower, according to Engelmann, has, by some, been considered of taxonomic value in *V. vinifera*. As has been noted, however, in wild vines of *V. bicolor* and *V. vulpina* the perfect flower with upright stamens was not observed in 347 individuals. Nevertheless, Beach ('98 and '99) and Booth ('02) have shown that in many cultivated forms with perfect flowers, having reflexed stamens, the pollen is abortive to a variable extent, this often rendering the flower pistillate,—at least functionally. Under similar conditions, also, vines are found bearing flowers with partially developed stigmas; and functionally these may be considered on the border line between the perfect and staminate forms. (PLATE 1, FIG. 9.)

Even taking into consideration these variations, there were observed to occur among the wild vines native to the region about Ithaca and Geneva, N. Y., only the staminate form and the perfect form with reflexed stamens. This would seem to indicate that the evolution is toward the dioecious habit.

In the genera closely related to *Vitis* there is a similar condition with respect to differentiation. According to Small, *Cissus* L. is perfect or sometimes polygamous, *Ampelopsis* Michx. mostly perfect, and *Parthenocissus* Planch. perfect or polygamo-monoecious. In this regard the degree of differentiation in *Vitis* and in the genera related to it is therefore considerable. These variations are both structural and functional. It is not clear which is the most primitive form, so that attempts to determine precisely the direction toward which evolutionary changes are now taking place would be largely speculation.

THE FLOWER CLUSTER: The branching habit of the grape is sympodial. The tendrils, or early in the growth of the shoot, the clusters, are the terminal growths of the stem. Upon further

elongation of the shoot new tendrils become terminal, while the older tendrils and clusters assume a lateral position upon the stem, opposite and alternating with the leaves. Intermediate forms between tendrils and flower clusters are common. Durand ('01) shows that in their origin and anatomical structure the grape tendrils and clusters are identical, and that they may change naturally one to the other. Tendrils frequently occur that bear a number of buds, the tendril retaining in such cases its irritability in the region of the buds and twining much in the same way as the normal tendril.

The flower clusters vary considerably, both in size and in number of clusters upon the cane, in the different varieties and species. Instances are common in the varieties of *V. Labrusca* in which five or more clusters are borne in succession on a single cane. This may be accounted for largely by the fact that in this species a tendril or cluster is usually borne opposite each leaf ("continuous tendrils"). In the other native species, which have no tendril or cluster for each third leaf ("intermittent tendrils"), the number of clusters per cane is reduced somewhat, the usual number being two or three.

The staminate cluster usually bears more flowers, has greater fragrance, and blooms earlier in the open than the perfect form. The flowers on the main axis of the cluster open commonly from one to four days or more earlier than those on the "shoulder." The blooming period of the different varieties and species varies much, and in the case of *V. vulpina* and *V. bicolor* the blooming periods rarely overlap, *V. bicolor* flowering last.

THE FLOWER: The grape flower is hypogynous. The calyx is represented by a narrow rim at the base of the flower. The normal perfect form has five green petals with five stamens opposite. Yellowish nectariferous glands occur between the stamens and are equal in number to them. There is a large sessile stigma. The carpels are from two to four in number, each usually with two ovules. The perfect form differs from the staminate merely in possessing a fully developed and functional pistil, this usually being abortive to the extent that no stigma is developed in the staminate flower.

Engelmann ('94) divides the pistil-bearing form into two types,

the "perfect" and the "imperfect hermaphrodites." This distinction was made as a result of the difference in the filaments; the "perfect hermaphrodite" having upright stamens (PLATE 1, FIG. 1); and the imperfect the reflexed stamens, in which the filaments curl back and down, bringing the anthers below the plane of the stigma (PLATE 1, FIG. 2). From the standpoint of self pollination this last mentioned position is an important consideration.

THE COROLLA: The corolla is gamopetalous; the united petals in the bud forming the "cap" (PLATE 1, FIG. 3 and 5). In the opening of the flower the petals break away at the base and remain united at the tips. This is one of the characters distinguishing *Vitis* from *Cissus*, the latter opening by breaking at the apex instead of at the base.

OPENING OF THE FLOWER: In the bud the cohering petals completely enclose the stamens and pistil. The first evidence that the flower is opening is the breaking away of the petals at the base. In most cases the break occurs at the base of one petal, the small fracture in the epidermis thus formed permitting further drying out of the surrounding tissue. Other petals break away at the base, curling as they break, thus separating one from another along the shallow sutures between. When the petals are released at one side, those on the opposite side hold fast. With further drying out, the tension brings the cap off sidewise, until it finally hangs by one petal, which soon breaks away, allowing the cap to fall (PLATE 1, FIG. 4 and 5). In other cases all the petals break away at about the same time, the individual petals gradually separating and curling up at the base, until they finally open wide and fall off. The cap may be only a few minutes in coming off, or it may remain partly open for several hours, depending upon the environmental conditions. Sometimes the cap breaks at the base and comes off almost instantly, the filaments gradually straightening out in the cases where the stamens are upright, or curling backward if the stamens are normally reflexed.

It is quite probable that the movements of the cap are primarily due to a drying out process rather than to pressure from the stamens. If the cap is removed, the separate petals soon curl up, as in the normal opening. In a very few cases the cap breaks

away at the top and the stamens extend through the slit. In some varieties this occurs more commonly at the beginning of the blooming season. The filaments are curled up under the cap before the flower opens and soon become straight and upright or reflexed (according to the flower type) when the cap is released or removed. In the wild staminate forms the filaments soon curl back, bringing the anthers near the base of the ovary (PLATE 1, FIG. 6). In some cases the cap will hold a part of the stamens together while one or more may be released, the latter soon curling backward if the stamens are reflexed. The flower opens in much the same way in all of the flower types. Beach ('92) observed that in a number of varieties the anthers opened before the cap was thrown off.

SPECIAL VARIATION IN FLOWER PARTS

VARIATION IN THE STAMEN NUMBER: There are usually five stamens in the grape flower. In order to determine how constant the number of stamens per flower is, the flowers on a number of clusters were classified with respect to stamen number. This classification shows considerable variation in the number of stamens per flower, both above and below the normal number five, and also that the proportion of flowers having either more or less than five stamens was nearly constant for the clusters of each vine. This proportion was found to be quite characteristic for each vine without regard to the type of flower, variety, or species. In a total of 115 clusters counted, not a single vine was found in which the proportion of flowers for each stamen number was not quite constant. The proportion may differ materially in the different vines of a variety, as in Petite Sirah, a variety of *V. vinifera;* on one vine (TABLE I) there are more flowers having five stamens than six, while on an adjacent vine there are more having six stamens than five.

TABLE I gives in a summarized form the data for all of the counts made; it includes for various species and certain cultivated varieties the total number of flowers per cluster, the number of flowers in each cluster for each stamen number, and the necessary indications respecting the type of flowers. The number of stamens varies from 3 to 9, or in other words, two below the usual number

TABLE I

Variety or species	Wild or cultivated	Sex	Clusters counted per vine	Class frequency for no. of stamens per flower							Total no. of flowers per cluster
				3	4	5	6	7	8	9	
V. aestivalis	C	♂	1		16	208	88	11			323
"	"	"	1		21	426	125	4			576
"	"	"	2		14	391	147	8			560
V. bicolor	W	♂	1	1	63	450	37				551
"	"	"	2		34	487	38				559
"	"	"	3	2	45	355	20				422
"	"	"	4		35	261	25				321
"	"	"	5		28	279	8				315
"	"	"	1		106	472	17				595
"	"	"	2		38	205	9				252
"	"	"	3		108	437	13				558
"	"	"	4		61	408	8				477
"	"	"	5		94	394	12				500
V. vulpina	W	♀	1		5	66	13				84
"	"	"	2		3	89	9				101
"	"	"	3		2	105	11				118
"	"	"	4			112	16				128
"	"	"	5		4	121	10				135
"	"	"	1		3	77	13				93
"	"	"	2		3	64	25				92
"	"	"	3		4	144	18				166
"	"	"	4		1	74	10				85
"	"	"	5		1	86	13				100
"	"	"	1		9	101	9				119
"	"	"	2		6	86	7				99
"	"	"	3		3	84	3				90
"	W	♂	1		78	298	5				381
"	"	"	2		86	279	6				371
"	"	"	3		94	308	7				409
"	"	"	1		49	362	20				431
"	"	"	2		44	237	9				290
"	"	"	3		60	203	13				276
"	"	"	4		50	176	7				233
"	"	"	5		121	294	9				424
"	"	"	6		81	303	9				393
"	"	"	7		69	240	6				315
"	"	"	1		43	82	7				132
"	"	"	2	1	28	140	8				177
"	"	"	3		34	109	6				149
"	"	"	4		15	113	23				151
"	"	"	5		33	191	23				247
"	"	"	6		35	92	8				135
"	"	"	7		32	128	12				172
"	"	"	8		33	190	21				244

Variety or species	Wild or cultivated	Sex	Clusters counted per vine	Class frequency for no. of stamens per flower							Total no. of flowers per cluster
				3	4	5	6	7	8	9	
V. vulpina	W	♂	9		21	211	12				244
"	"	"	10		28	118	4				150
"	"	"	11		31	177	9				217
"	"	"	12		26	194	8				228
"	"	"	13		21	238	13				272
"	"	"	14		18	259	15				292
"	W	♂ ♀	1		23	427	127	2			579
"	"	"	2		11	159	38	1			209
"	"	"	3		32	372	65	1			470
"	"	"	4		24	481	156				661
"	W	♂	1		60	347	63				470
"	"	"	2		29	325	72				426
"	"	"	3		10	362	65				437
"	"	"	4		18	348	91				457
"	"	"	5		24	416	70				510
"	"	"	1		9	328	190	9	2		538
"	"	"	2		15	383	302	38			738
"	"	"	3		23	209	81	2			315
"	"	"	4		26	424	161	7			618
Concord (*V. Lab.*)	C	♀♂	1		4	67	30				101
"	"	"	2		2	32	22	2			58
"	"	"	3		1	61	26	2			90
"	"	"	4		3	75	9	1			88
Brighton (*Lab., vin.*)	C	♀	1		13	74	38	2			127
" "	"	"	2		11	83	22	1			117
" "	"	"	3		7	76	32	3			118
Hybrid Franc (*vin., rup.*)	C	♀♂	1		1	47	83	6			137
" "	"	"	2		1	34	106	6			147
" " "	"	"	3		1	27	74	11	1		114
Jaeger No. 43 (*vin.*)	C	♀	1			33	117	35	2		187
" "	"	"	2			22	123	47	1		193
Janesville (*Lab., vulp.*)	C	♀♂	1			4	47	46	6	1	104
" "	"	"	2		1	5	59	56	6		127
" "	"	"	3			2	56	66	11	1	136
" "	"	"	4			3	32	32	2		69
" "	"	"	5			3	41	41	8		93
" "	"	"	6			1	41	47	8	1	98
Massasoit (*Lab., vin.*)	C	♀	1		10	81	77	7			175
" "	"	"	2		7	56	50	6			119
" "	"	"	3		3	42	38	6			89
Norton (*aest., Lab.*)	C	♀♂	1			1	18	46	18	2	85
" "	"	"	2			6	52	64	14	1	137

Variety or species	Wild or cultivated	Sex	Clusters counted per vine	Class frequency for no. of stamens per flower							Total no. of flowers per cluster
				3	4	5	6	7	8	9	
Petite Sirah (*vin.*) *	C	☿	1		2	172	93	1			268
" " "	"	"	2		6	195	88	3			292
" " "	"	"	3		2	118	47				167
" " " †	"	"	1		4	109	46	1			160
" " "	"	"	2		8	192	78	2			280
" " " *	"	"	1		1	73	111	5			190
" " "	"	"	2		4	88	128	4			224
" " "	"	"	3		5	83	106	1			195
" " " †	"	"	1		9	52	65	2			128
Seibel No. 2	"	"	1			34	121	15			170
"	"	"	2			27	104	24	1		156
"	"	"	3			49	122	8			179
"	"	"	4			19	115	30	1		165
V. Labrusca (small cluster)	W	♂	1		1	14	9				24
Cross (*Lab.* × *vin.*)	C	?	1		35	285	51	1			372
" "	"	"	2		38	383	117	2			540
" "	"	"	3		6	128	48	1			183
Cross (*Lab.* × *vulp.*)	C	♂ ♀	1		13	408	69	4			494
" "	"	"	2		9	561	73	2			645
" "	"	"	3		5	224	52	3			284
" "	"	"	4		5	284	49	2			340
" "	"	"	5	1	14	176	67	2			260
" "	"	"	6		13	235	121	11			380
Cross (*Lab.* × *bic.* × *vin.*)	C	♂	1	1	41	105	8				155
" "	"	"	2		18	60	6				84
Cross (*Lab.* × *vin.*)	"	"	1		4	139	77	8			228
" "	"	"	2		3	159	181	35	1		379
Cross (*Lab.* × *vin.* × *bic.*)	"	"	1		63	260	15				338
" "	"	"	2		115	413	24				552
Total			115	6	2,630	21,385	5,829	783	82	6	30,721

* Counted in 1909.

† Counted in 1910.

and four above it. The highest number of flowers found in any cluster was 738, which occurred in a wild vine of *V. vulpina*. The staminate cluster usually has more flowers than either form of the perfect.

It will be seen from an inspection of TABLE I that the variation

in the stamen number has, in general, a definite direction in the flowers of each vine. In most cases the mode falls on five, but in some of the cultivated varieties, as in Jaeger No. 43 and Seibel No. 2, the mode is distinctly on six; while in Janesville there are only a few flowers having five stamens, with the number having six and seven practically equal, more having eight stamens than five, and three flowers having nine. This is a striking variation from the usual number five. Among those included in this table there were no flowers observed having double the number of stamens, the nearest approach to this being nine.

The summary of TABLE I, giving the total number of flowers for each stamen number, shows considerable variation in the number of stamens per flower in *Vitis*. The stamen number is variable in all the clusters included, whether of a species, variety, or cross. Out of a total of 30,721 grape flowers in which the stamens were counted, there are more (21,385) having five stamens than any other number; more (5,829) having six stamens than four, which is represented by 2,630 flowers; 783 have seven stamens and 82 have eight; while the two extremes are represented by much smaller numbers, 6 having nine stamens and 6 also three. The trend of the variation, therefore, is toward an increase in the number of stamens rather than a decrease.

VARIATION IN COROLLA NUMBER: The number of parts to the cap is usually the same as the number of stamens (PLATE 1, FIG. 3 and 5). Exceptions to this occur where two small stamens are found opposite one petal, or where two filaments are united more or less throughout their entire length; but this occurs so seldom, and the relation between the petal and the stamen number is so close, that TABLE I may be regarded as showing fairly accurately the variation in the number of petals in the cap as well as the stamen number.

VARIATIONS IN THE NECTARIFEROUS GLANDS: The nectariferous glands vary much in color and size; they also correspond very closely in number with the stamens and petals. On some vines they are pale yellow while in other cases they are a dark yellow or yellowish green. On some of the cultivated varieties, as Concord and Worden of the blue varieties, and Diamond, Leader, or Pocklington of the green, they still persist in the mature berry

as yellowish or brownish dots around the base of the pedicel. In PLATE 1, FIG. 7, 8, and 9, are shown some of the forms they assume in the staminate flower. In FIG. 7 (PLATE 1) the nectariferous gland forms a distinct five-sided ridge around the abortive pistil; in FIG. 8 (PLATE 1) the glands protrude distinctly between the stamens; and in FIG. 1 (PLATE 1) they are shown in the perfect flower. Closely observed, this organ exhibits differences in almost every vine.

VARIATION IN THE PISTIL: Where the number of stamens varies either above or below the usual number five, changes result in both the external and internal structure of the ovary. Externally the number of lateral surfaces of the pistil vary and correspond in number to the stamens. Internally there is associated with an increase in the number of stamens a larger number of carpels, and likewise more ovules or seeds per berry. The number of carpels may be independent of the number of parts to the flower, but in general there seems to be a relation between them. In one cluster of Janesville, in which the seeds were counted, there were for each stamen number, 4 berries that had five stamens, and all had two carpels; of the 29 berries that had six stamens 22 had 2 carpels and 7 had three; 23 had seven stamens, and of these 15 had 2 carpels and 8 had 3; 5 berries had eight stamens, one of which had 2 carpels and 4 had three. In the staminate flowers this relation, of course, would not hold.

STRUCTURAL VARIATION IN THE STIGMA: A careful distinction does not seem to have been made by previous writers on this subject between the stigma and pistil. Engelmann ('94) observes that "the sterile plants do bear male flowers with abortive pistils, so that while they never produce fruit themselves they may assist in fertilizing the others." Booth ('02) states that "all of the staminate flowers, so called, which I have observed, have small abortive pistils; which also conforms with the observations of Engelmann. Others report staminate flowers with no trace of pistil remaining." In the same publication he states further that "there is a vine on this station which bears both staminate and hermaphrodite flowers. Mr. N. B. White, Norwood, Mass., reports that he has a male (?) *Rip.* × *Lab.* vine which has fruited twice in the last thirty years, the pistils evidently varying in

strength but being generally too weak to produce fruit." Munson ('99) mentions that it is clear that the staminate vine can not bear since it has no pistil, "unless the vine changes its action from producing purely staminate flowers to bearing pistillate flowers, which in two or three instances only, in all my observation, I have known to occur."

In the instance mentioned by White, the stigma probably had a development similar to that shown in FIG. 10, PLATE 2, which is a photograph of two clusters from one cane of a Marian × Pocklington cross, which grew in the vineyard of the New York State Experiment Station. It will be seen from this photograph that the flowers of this vine are functionally so nearly midway between the pistillate and perfect forms that on the same cluster some pistils have sufficient stigmatic tissue to permit of pollen germination, while others do not. During the three seasons in which the writer had the opportunity to observe this vine some clusters bore fruit each season. In PLATE 2, FIG. 15–18, there are shown photomicrographs of median sections of four pistils from this vine. Flowers with a similar stigmatic development have been observed by the writer on two wild vines of *V. vulpina* and also in a number of crosses at the New York State Experiment Station, in which *V. Labrusca*, *V. bicolor*, *V. vulpina*, and *V. vinifera* occurred.

The series of median sections included (PLATES 2 and 3, FIG. 11–24) shows practically all gradations in stigmatic development between the truly perfect and the staminate forms. Even the purely staminate forms represented (PLATE 3, FIG. 19–24) in the sections show an abortive pistil with no stigmatic tissue, yet having carpels and rudimentary ovules. The statement of Booth ('02) that all staminate flowers observed have small abortive pistils is corroborated. By following the series, then, it will be seen that the seed coats in the ovules are not fully developed in staminate forms and only partially so in some of the intermediate forms with small stigmatic surfaces. This fact is significant in that it indicates, that there is not a complete segregation of the pistillate and staminate forms but a suppression of pistil development in the case of the staminate flowers.

Median sections through the pistils of some of the intermediate

forms are shown in PLATE 2, FIG. 15–18; these show different stages of stigmatic development occurring on different vines. The seed coats in the ovules show considerable development in PLATE 2, FIG. 14–18. The material, with the exception of PLATE 3, FIG. 21–24, was all fixed just after the flower was completely open, so there is probably not more than one or two days' difference in their relative ages; the others were fixed before blooming, to show the relative position of the anthers, filaments, and pistils in the bud. The crouched position of the filaments will be noted in PLATE 3, FIG. 22. In many flowers, however, the filaments are even more crouched and bent than in this instance.

SOME ABNORMALITIES OF THE PISTIL: Cases are rarely observed in which one or more anthers of a flower may be found with the filament adhering to the side of the pistil, the tissue of both filament and pistil being united. In this way the stigmatic tissue and the anthers, sometimes partly abortive or deformed, are brought into very close contact. Some abnormalities of this nature have been observed where the stigmatic and anther tissues are intermingled, the pollen being to all appearances normal. This adherence is probably due to a lack of differentiation in the meristem and does not seem to be a case similar to that observed by Chamberlain ('97) in *Salix petiolaris*, in which microsporangia were found in the placenta of the ovary, as well as stigmas developing on stamens.

Some vines bear flowers with distinctly pinkish stigmas. The writer has observed this in a few wild vines of both *V. vulpina* and *V. bicolor*, and also in a number of cultivated varieties, as in the R. W. Munson. The stigma is distinctly lobed in some vines, both cultivated and wild, the lobes generally corresponding to the carpels. In varieties like the Goff, where many grapes on a cluster show distinct sutures, varying in number from one to three or four, this tendency can be seen soon after blooming; and in a few extreme cases the pistil may be nearly separated into two parts. In outline the stigmatic surface varies much, being oval, flaring or flat. Under favorable conditions the stigma may become receptive before the corolla opens. This condition was observed by the writer in both Concord and Hubbard Seedless.

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SUMMARY

Vitis is dioecious, polygamodioecious, or perfect. The flower forms which occur are the staminate, and the perfect (1) with upright and (2) with reflexed stamens. Individual vines either within the variety or species are quite distinct with respect to these flower forms. In *Vitis* the flower forms resemble those of the closely related genera, *Cissus* L., *Ampelopsis* Michx., and *Parthenocissus* Planch. The direction of the evolutionary changes in the flower forms is not entirely clear.

The typical staminate cluster is larger than either form of the pistil-bearing. The typical grape flower is 5-merous, although about 30 per cent show a variation from this plan. The petals, nectariferous glands, and stamens correspond closely in number. The dehiscence of the corolla seems to result largely from a drying-out process rather than from being pushed off by the straightening out of the filaments.

The number of stamens per flower was found to vary from three to nine, the variation being independent of the flower form, variety, or species. The flowers from different clusters of the same vine show in general the frequency of distribution that is characteristic of the vine. Clusters from different vines may have different arrays. When the stamens are increased or decreased, the petals and nectariferous glands, in general, correspond in number. An increase in the number of stamens is associated with an increase in the number of carpels. In short, the numerical relations of the members of the floral whorls are commonly maintained.

In occasional vines the stigma is, throughout, only partially developed. This condition may be regarded as an intermediate form between the pistil-bearing and the staminate forms, both in structure and function. The staminate flowers have rudimentary pistils, in which the stigmas and ovules are abortive.

The variations in the flower of *Vitis* may be grouped into two classes: first, meristic, which would include differences in the number of the organs per flower; and, second, functional, including variations in the extent of development of the pollen, stigma, and ovules.

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Explanation of plates 1–3

PLATE 1

FIG. 1. The perfect flower with upright stamens.

FIG. 2 and 6. The perfect flower with reflexed stamens; FIG. 6, wild *Vitis vulpina*.

FIG. 4 and 5. The position of the stamens and corolla in different stages in the opening of the grape flower.

FIG. 3 and 5. United petals forming the "cap," also differences in the number of petals in the corolla.

FIG. 7, 8, and 9. Different forms of nectariferous glands in staminate flowers

PLATE 2

FIG. 10. Photograph of two clusters from the same cane of a Marian × Pocklington cross, showing enlargement of the pistil in cases where only partially developed stigmas were present.

FIG. 11–18. A series of photomicrographs of median sections through pistils having stigmatic tissue developed in different degrees.

PLATE 3

FIG. 19–24. A continuation of the series 11–18, PLATE 2, showing median sections through the pistils of the grape; these would usually be classed as staminate flowers.

FIG. 21, 22, 23, and 24 are median sections of unopened buds showing the relative position of the calyx, corolla, stamens, and pistil. The crouched position of the filaments is shown in FIG. 22.

The relation of Ohio bog vegetation to the chemical nature of peat soils*

ALFRED DACHNOWSKI

The ecological relation of plants to soils, particularly to the chemical nature of the substratum, is especially interesting and has been extensively studied from the standpoint of the distribution of species, the succession of vegetation, and the adaptability of crops to certain soils. In mountainous countries and even in states like Ohio, with soils of morainal and of varied geognostic nature, one can observe sharply delimited distinctions in the distribution and in the whole appearance of vegetation units. And yet, though many species are confined to soils with a definite chemical relationship, a great many plants can grow on soils widely dissimilar in kind. Are the reasons for the generally observed distinctions to be sought in the chemical constitution of the soil, or is the distributional relationship due to the physical characters, particularly to relations prevailing in regard to the amount of available water and the specific quantity required by the plants, and to the thermal condition in the soil?

Not all field work is adapted to throw light on this vexed question of a long standing dispute. Difficult as is the attempt to establish a correlation between vegetation and any one factor of the environment, it is possible, however, to make such a correlation with peat soils, within the area here investigated.

It is now generally recognized that the nature of a lake and bog environment is constantly selective, and that the associations and societies of plants succeeding one another are each characterized by a definite physiognomy in response to their dependence upon soil conditions under atmospheric influences essentially similar otherwise. In an earlier paper the writer has listed the successions of the more genetically related vegetation units, their associations and societies, occurring in Ohio lakes and peat deposits (Plant World **15**: 25–39. 1912).

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In connection with the problem of the utilization of Ohio peat, both chemical and calorimetric analyses were made of the peat samples collected. With the exception of the potash, phosphoric acid, and lime analyses, and the analyses of TABLES II and III, all determinations were made under the auspices of the United States Bureau of Mines as a part of more general investigations of the fuels of the United States. This cooperative work between the State and the Federal Government has been made possible through the considerate and helpful interest of Dr. Charles A. Davis, in charge of the peat investigations of the U. S. Bureau of Mines.

The analyses, as might be expected, vary widely, but there is a certain uniformity in regard to their chemical character. The analyses show the following range in chemical composition:

TABLE I

CHEMICAL ANALYSES OF OHIO PEAT. RANGE OF CHEMICAL COMPOSITION

	Minimum	Maximum
Volatile combustible	50.99	74.79
Fixed carbon	16.56	33.64
Ash	3.65	25.44
Nitrogen	1.01	3.68
Potash (K_2O)	0.10	0.98
Phosphoric acid (P_2O_5)	0.03	0.50
Lime (CaO)	0.00	4.52
Thermal value: calories	3,962.00	5,409.00

Through the courtesy of Professor J. W. Ames of the Wooster (Ohio) Experiment Station a more detailed analysis of the ash of peat soil is here appended in TABLE II.

TABLE II

ANALYSES OF PEAT SOILS, CHEMICAL DEPARTMENT, OHIO AGR. EXP. STATION
TOTAL AMOUNTS FOUND

Lab. no.	Locality	Ash	Mn	SiO_2	SO_3	Al_2O_3 and Fe_2O_3	CaO	MgO	Na_2O	P_2O_5	K_2O	N
5302	Akron	9.66	.0056	3.21	1.20	2.04	2.390	.311	——	.299	.1594	3.42
5303	"	14.58	.0099	6.18	.97	2.91	2.870	.331	——	.345	.3117	3.24
5304	"	9.84	.0220	4.05	1.03	2.19	3.580	.361	——	.342	.1531	3.38
5305	"	14.38	.0332	5.26	1.03	2.44	3.650	.297	——	.469	.2956	3.10
5306	"	11.65	.0515	4.01	.88	2.65	2.800	.345	——	.337	.1860	3.18
14460	Lodi	——	——	——	——	5.15	4.529	.570	2.366	.506	.4753	——
14461	"	——	——	——	——	4.24	2.570	.420	3.373	.342	.3239	——
14462	"	——	——	——	——	5.62	4.060	.650	2.040	.374	.3569	——
14463	"	——	——	——	——	11.15	2.210	.660	1.944	.256	.9835	——
14464	"	——	——	——	——	4.08	3.050	.630	1.066	.373	.3376	——
14465	"	——	——	——	——	4.18	2.340	.420	2.018	.429	.3445	——
14162	McGuffey	——	——	——	——	——	3.585	——	——	.370	.4720	2.48

The water from peat soils is relatively clear; in several places of the state it is used occasionally for drinking purposes. The suspended particles impart to it a tinge of color from olive green to brown. Analyses of samples of bog water and bog lake water give the following results:

TABLE III

CHEMICAL ANALYSES OF BOG WATER AND LAKE WATER FROM CRANBERRY ISLAND, BUCKEYE LAKE

Constituents in parts per million	Bog water from cranberry-sphagnum association	Bog water from alder-shrub association	Lake water
Nitrogen as albuminoid ammonia	10.34	11.48	4.50
Nitrogen as free ammonia	15.19	8.24	2.95
Nitrogen as nitrites	0.0005	0.0003	0.00000
Nitrogen as nitrates	0.20	0.20	0.1000
Chlorin	0.30	1.00	1.00
Required oxygen	71.80	70.30	3.70
Alkalinity (as $CaCO_3$)	30.00	40.00	75.00
Incrustants (as $CaCO_3$)	74.00	72.00	76.00
Total solids	140.00	160.00	200.00
Loss on ignition	100.00	20.00	4.00

The osmotic pressure of these solutions is the same as that of Ohio lakes, the average lowering of the freezing point varying between 0°.005 and 0°.010 when compared with that of distilled water. The acidity of the solutions varies from less than 0.00075 to 0.004 normal acid when titrated with an 0.05 NaOH solution and phenolphthalein.*

The several analyses submitted do not reveal the obvious distinction between successions of vegetation on peat soils and the changes in the chemical character of the peat. The fact that certain plant associations have an absolutely defined morphological and topographic distinction, and the fact that these contrasts must be attributed to conditions prevailing in the soil, directs special attention to the contrasts between peat soils of the various vegetation units or groups of plants. The following series in TABLE IV is especially suggestive in showing the more typical features of the correlation.

* Livingston, B. E. The physiological properties of bog water. Bot. Gaz. 39: 348–355. 1905.

The correlation phenomena between vegetation units in bogs and the character of the peat soil are not in all cases as those given in TABLE IV. There are many exceptions to the rule for reasons

TABLE IV

CORRELATION BETWEEN VEGETATION UNITS IN OHIO BOGS AND CHARACTER OF PEAT SOILS

Vegetation unit Locality	Moisture in air-dried sample.	Volatile matter	Fixed carbon	Ash	Nitrogen	Potash, K_2O	Phosphoric acid P_2O_5	Sulphur	Calorific value: calories
Bog meadow succession. Cranberry-sphagnum association.									
Buckeye Lake, No. 41 ...	9.23	67.99	24.46	8.45	1.01	0.12	0.03	0.43	4792
Lakeville, Holmes, No. 72	6.96	69.15	25.04	5.81	2.38			0.23	5317
Lakeville, No. 73.....	7.14	67.42	24.91	7.67	2.39			0.28	5039
Bog shrub succession. Alder-maple association.									
Buckeye Lake, No. 43 ...	9.90	61.63	27.11	11.26	2.21	0.12	0.03	0.64	4512
Orrville, No. 44.....	9.08	63.24	26.18	10.58	2.45			0.46	4981
Bog forest succession. Tamarack association.									
Canton, No. 76.....	8.01	62.03	31.84	6.35	3.39			0.33	4912
Fox Lake, No. 78.....	8.99	54.46	25.02	20.52	2.41	0.15	0.28	0.89	4375
Mesophytic forest succession. Maple-ash-elm association.									
Mantua Bog, No. 47	10.40	56.33	26.16	17.51	2.46	0.19	0.42	0.86	4550
Bradley Pond, No. 51 ...	10.11	60.09	27.96	11.95	2.24	0.27	0.19	0.29	4856
Copley Bog, No. 59	11.35	56.85	31.87	11.28	2.72			0.89	4923

that will be stated below. On the whole, however, the results may be summarized in the following well-defined relations:

1. In color Ohio peat ranges from a greenish and grayish brown, due to the presence of clay and marl, through various shades of brown to an almost black variety. In texture peat varies from a loosely compacted fibrous heterogeneous meshwork of plant debris to the fiberless, homogeneous variety.

2. The physical water content of peat is higher in the coarser fibrous substratum of the bog meadow association. The mat, when adjoining open water, adjusts itself easily to changes in the water level of the basin. With the disintegration of the plant tissues the water-holding capacity of peat is higher. The concentration of the peat solutions is very low, varying in parts per million

between 40 and 260 parts of total solids. The osmotic pressure and the acidity of the soil solutions differ but slightly between the various grades of peat soil.

3. Reducing processes in peat soils, judged by methylene blue or a one per cent starch-iodid solution, increase from any marginal point of a peat-depositing lake to the bog meadow association and decrease as the deciduous forest association is approached.

4. The nature of the changes which have taken place in the transformation of vegetable debris into peat is only partly understood. The principal changes are a relative loss in oxygen and hydrogen and a progressive increase in carbon and nitrogen. This is clearly shown in passing from the fibrous peat substratum of bog meadows to the structureless peat occupied by bog forests and deciduous trees.

5. In poorly decomposed peat the percentage of volatile combustible material is high, the percentage of fixed carbon, of nitrogen and ash is low. In well decayed peat the reverse is true.

6. The higher ash content in peat from bog shrub and bog forest associations is believed to be due largely to windblown silt; a bog meadow association interferes less with wind work than the timbered area of a deposit.*

7. Peat contains potash and phosphoric acid in comparatively inconsiderable quantities, only a fraction of one per cent, whereas the percentage of calcium and nitrogen is very high, varying from one to almost four per cent. The capabilities of a soil for crop production are usually judged from the study of the chemical character of the soil, and soils markedly deficient in phosphates, potash, and other salts, are looked upon as barren and sterile. Maintenance of fertility is connected with abundance of these constituents. In peat soils, it seems, the essential mineral salts of the agricultural tripod play only minor rôles for protoplasmic activities and in the growth and ripening of bog plants.

8. More systematic investigations from the standpoint of agricultural chemistry have shown that the number of possible inorganic nitrogenous substances, the quantity of nitrites, nitrates, and ammonia is quite small, ranging from a few thousandths to a few hundredths of one per cent. Practically all the nitrogen contained is, therefore, of organic nature.

* Beyer, S. W. Peat deposits in Iowa. Iowa Geol. Sur. **19**: 698. 1908.

9. Only a small amount of nitrogenous bodies can be extracted from peat by means of water. The relatively low free ammonia and the large amount of oxygen consumed indicate that the organic matter is not in an advanced state of decomposition.

10. The solubility of a coarsely fibrous peat is less than that of peat in a finer state of division and more advanced stage of disintegration. This condition seems to point to the fact that the organic compounds arise mainly through the action of micro-organisms. Compounds associated with the decomposition products of proteids by mineral acids, are here practically out of the question.

11. Little is known as to the chemical constitution of peat and of the transition and decomposition products of proteids and carbohydrates arising in peat soils. Biochemical technique has not permitted, as yet, the analysis or the preparation of isolated peat soil constituents of comparative purity. They are undoubtedly of access for chemical investigation and isolation. Known methods of investigation of proteids have been applied in the study of the decomposition products of organic compounds in soils.

Schreiner and Schorey,* Jodidi,† and Robinson‡ have more recently isolated and identified a number of these bodies. In peat soils, however, the compounds are present in small amounts, the number of transition products is undoubtedly larger, and their effects upon living plants is as yet unknown. It is difficult to understand how a substance present in peat soils or in bog water in such minute concentration that for ordinary chemical analysis its influence is negligible, may nevertheless exert a profound effect upon the growth of plants. It is not necessary to assume that this distinctly disproportionate effect is produced by external chemical action, by enzymes, or by biological metabolic products. Peat is a heterogeneous system of substances, and its variable composition renders it difficult to determine what substances are injurious and what substances can actually be absorbed and

* Schreiner, O., and Schorey, E. C. Chemical nature of soil organic matter. U. S. Dept. Agr. Bur. Soils Bull. 74. 1910.

† Jodidi, S. L. Organic nitrogenous compounds in peat soils. Michigan Agr. Coll. Exp. Sta. Tech. Bull. 4. 1909.

‡ Robinson, C. S. Organic nitrogenous compounds in peat soils. II. Michigan Agr. Coll. Exp. Sta. Tech. Bull. 7. 1911.

assimilated by plants. The presence of one substance or the concentration of another constituent as determined by quantitative analysis may have only an apparent relation but not necessarily a causal value. This might be for the reason that the substances are differently distributed on account of differences in solubility or oxidation, are absent in one phase of the decomposition process because of differences in the bacterial flora at work in different layers, or vary greatly with reference to the diosmotic properties of the absorbing organs of plants. Humus has long been recognized as a very important factor in soil fertility, and yet almost all the difficulties in any special problem with humus or peat arise in the lack of knowledge of the chemical nature and the effects on plant life of the various organic compounds resulting from weathering processes and from the activity of microorganisms. The complexity of the problem emphasizes the need of physiological studies. The bacteriological-chemical and the physiological analyses deserve on that account a closer consideration. The writer's method of determining the transformation products in various media inoculated with bog bacteria should possess the exactness and reliability necessary for the solution of this problem. The determination of these bodies by chemical means alone will be only in part of value for investigations in ecology.

Numerous problems of experimentation have arisen quite apart from the main question itself.

It would be interesting to determine the water requirement of bog plants for a growing period and to compile the results on a basis of the water needed for one part of ash yielded. Data on the specific differences in the ratio, i. e., on the water requirements of bog plants and the percentage of ash in herbs, shrubs, and trees covering peaty basins, are not at hand. The analyses reported by C. S. Sargent in the ninth Census of the forest trees of North America give the percentages for some of the trees common to bogs. The data are interesting in showing that the majority of trees frequenting bogs have a percentage of ash less than 0.5, and only a few of the deciduous species occurring on Ohio peat deposits have a percentage of ash as high as 1.5. Comparisons of the quantities of mineral salts contained in peat deposits, differing so widely in

ash constituents from land soils, point also to the fact that differences in mineral components are trifling as compared with the biological processes in the substratum and the differences in the available water.

It remains to be ascertained to what extent the absence of any mineral salt may lead to the unbalanced condition which induces the general pathological effects upon agricultural plants, and whether any one of the salts employed in fertilizers may in part or entirely counteract the injurious effects of peat and humus soils. Plant physiological and particularly agricultural literature contains numerous references to the rôle of mineral salts as nutriments. It must be candidly admitted, that the effects of the various mineral salts produced upon the plant or the cell are far more easily formulated than proved and that a satisfactory interpretation is not possible as yet. It is now known that in the preparation of mineral solutions for plants a certain ratio of the different salts is required. It would be of special interest to note in some detail the relation of potassium and calcium compounds, and the suitable concentrations required to counteract the toxicity of the deleterious bodies in peat soils. The fact that water and salts are as a general rule taken up in a different ratio, differing also according to the species of plants used as an indicator, shows that the relation in balanced solutions affects and is determined primarily by the diosmotic properties of the protoplasmic membrane and its accommodatory processes. The direct effect of mineral salts on the protoplasmic membrane is undoubtedly of greater importance than their supposedly special nutrient value. Tolerance and resistance of plants to physiologically deleterious substances, it may be added, is not one of osmotic relations to bog water, nor is the absorption of water a function of it. A study of the magnitude of the internal osmotic pressure occurring in the roots and in the foliage of bog plants as related to bog conditions has not been carried very far as yet. Wheat plants growing in bog soils do not, however, show more than the usual pressure* isotonic with a 0.3 normal solution of potassium nitrate.

Elsewhere (Bot. Gaz. **49**: 325–339. 1910; and **52**: 1–33. 1911) the writer has shown that contrary to the position taken by

* Fitting, H. Die Wasserversorgung und die osmotischen Druckverhältnisse der Wüstenpflanzen. Zeits. Bot. **3**: 209–275. 1911.

several investigators, peat soils contain bacteria inducing diastatic, inverting, proteolytic, cytohydrolytic, and reducing actions during the digestion of the plant debris in the upper layer of the peat substratum. A marked interdependence was shown to exist between the organisms; and the fact that many organisms are obligate saprophytes capable of growing only on a substratum similar in composition to the character of the respective plant association, is indicative of a close relation between a specific bacterial flora, the progressive disintegration of organic material, and the successions of vegetation in bogs and peat deposits. The characteristic xerophily of ancient* and modern bogs the writer attributes to the edaphic adversities encountered rather than to climatic differences. Though the biological processes in the soil thus appear to be more essential than the quantity of mineral components, there yet remains the question how far microorganisms are active in the change of vegetable matter to peat and lignite, and in the formation of gases and of coal. To what extent is the cooperation either essential, useful, or dangerous in the formation and character of organic compounds available for assimilation? What are the factors affecting and limiting the decomposition of organic matter?

What is the nutritive value of the different carbon and nitrogen compounds arising through the activity of microorganisms? Toxic substances possess an unlike physiological value to different plants and hence it is but one step further to raise the question of the comparative nutrient value of these organic compounds.† More recent experiments with isolated bog bacteria show very clearly the ability of a number of the organisms to increase the amount of assimilable compounds in peat soils. The transpiration values of these cultures for wheat plants lie 200 per cent above that of the control. The fact that to many plants bog toxins are injurious at one concentration but not at another, and that further dilution carries with it a corresponding intensification in

* Dachnowski, A. The problem of xeromorphy in the vegetation of the Carboniferous Period. Am. Jour. Sci. IV. **32**: 33–39. 1911.

† Haskins, H. D. The utilization of peat in agriculture. Massachusetts Agr. Exp. Sta. Rep. **1909**[2]: 39–45. 1909.

Lipman, F. G. Report of the Soil Chemist and Bacteriologist of the New Jersey Agr. Exp. Sta. 188–195. 1910.

growth rate, shows the inefficiency of the usual analytical methods of the organic chemist. Neither the properties, the chemical formula, nor their effect upon transpiration, alone afford an indication of their physiological importance. In addition new analyses of peat, wood, and of bog plants from various zones with reference especially to the ratio between the carbon and nitrogen content, are much to be desired. A study of the relative toxicity of the substratum is not independent from a study of the energy needs of the organism. Both are equally important and must be approached from the point of view of the possible absorption and transformation of the compounds or their neutralization into insoluble, impermeable compounds, and the specific structural and functional peculiarities in plants enabling the change.

Aside from the nutritive inequalities of organic peat soil constituents it is worth while to study more closely the various structural modifications that appear in plants indigenous to the habitat, in the less fit invading plants, and in those which survive. In another paper the writer has shown that the phenomena of absorption and tolerance of plants in bogs deal with consideration of the permeability of the absorbing protoplasmic membrane, its power of endurance and its ability either to absorb and assimilate or to transform injurious bodies into impermeable compounds. The form of invading plants is frequently altered, as is shown by dwarfing, the reduction of number and size of leaves, the loss of buds and branches, and the rapid aging of the plants. This indicates the extent to which the various functional mechanisms involved, such as absorption, conduction, and growth, are interrelated and coordinated. Every green plant is undoubtedly able to a certain extent, to assimilate nitrogenous and other organic compounds. Plants that grow preferably on humus and peat soils must have special absorptive powers, but little is known, as yet, to what extent the roots themselves exert a direct solvent action, enzymatic or otherwise, in rendering the peat available for assimilation, and how far fungal mycorhiza, which form symbiotic unions, are of importance.

The possible scope of this study has been barely indicated.

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Studies in pyrophilous fungi—III.* The viability of the spores of Pyronema

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(WITH PLATE 4)

In the first paper of the present series, in attempting to impress upon botanists the value of *Pyronema* as a plant to be used in regular class study, it was stated that no data were at hand as to the length of time during which the spores of this fungus would keep their viability. As a knowledge of this point is of vital importance in determining whether the teacher is able to tide over this plant in the laboratory from year to year, it is deemed worthy of special study and mention at this time.

As has been previously stated, when once this fungus has been cultivated it is comparatively easy to "get a catch" from the air by simply exposing properly heated soil and keeping it moist for a few days. Especially is this true in greenhouses. To my knowledge, since this fungus has been under observation here, steamed or heated soil used for planting in the propagating houses of the New York Botanical Garden has never failed to develop the fungus. Some time ago the spores of the fungus were sent to Purdue University for experimental purposes, and recently in a conversation with Dr. F. D. Kern he informed me that this fungus also now made its appearance in their greenhouse whenever heated soil was exposed. While the fungus may usually be obtained in this way when once it is started, this method is uncertain and the occurrence of the plant is likely to be delayed when it is most needed. It is therefore better to develop and rely upon some more certain methods of securing and preserving it.

During the present winter the fungus was desired for study in classes at Columbia University, and several pots of heated soil were exposed to the air, as formerly, in the laboratories of the

* Studies in pyrophilous fungi—II. Changes brought about by the heating of soils and their relation to the growth of *Pyronema* and other fungi, was published in Mycologia 2: 109–124. *pl. 24–26.* 1910.

New York Botanical Garden. As it had been some time since the fungus had been under cultivation at the Garden, the spores were apparently not very numerous in the air, for after several days the plant failed to appear. Search was then made for some recently collected spores for inoculation. No attempt had been made to keep the spores for this purpose and the youngest specimens available in the herbarium of the Garden had been collected nearly three years before. The soil was inoculated with these aged spores, and within a few days a good growth of *Pyronema* was produced, the infection apparently proceeding from the point of inoculation. As this experiment did not prove with certainty that the old spores germinated, it was decided to test them out in hanging drop culture.

A complete history of the specimen used in the above experiment is as follows. In the spring of 1909, a pile of leaves and brush was burned, and this opportunity was taken to test the growth of *Pyronema* under natural conditions, as the fungus was at that time under cultivation in the laboratory. Spores were taken from the plants grown in the laboratory and with these the burned place was inoculated. In a reasonably short time our burned place showed a good growth of the fungus. One good specimen was collected and placed in the herbarium of the Garden in an ordinary paper packet. In January 1912 the spores from this specimen were used for the experiment described above, and while many of the spores failed to germinate, there was enough growth in a hanging drop culture to form a web of mycelium over the cover glass on which the spores were planted.

The spores of *Pyronema* are rather thin-walled and are not the kind of spores, so far as general appearance is concerned, that would be expected to keep their viability for a long period of time. Also, it would naturally be thought that spores which are adapted to withstand long periods of unfavorable conditions as resting spores would not germinate readily when fresh. The spores of this fungus are an exception in both of these particulars, for the fresh spores germinate very readily in hanging drop culture and very old spores germinate with equal facility; also, the walls of the spores do not appear to be thicker than the walls of the young mycelium and show no protective structures.

The spores germinate by putting out a germ tube from each end, one end, however, growing much faster than the other. The young mycelium is very coarse, the diameters of the main branches being fairly constant. The whole mycelium is filled with vacuoles, giving it a characteristic appearance. The spore before germinating swells much, becoming large and very granular. The germ tube as it issues from the spore is slightly smaller in diameter than the spore but often swells to about the same diameter. The contents of the spore after germination are similar in appearance to the contents of the young mycelium, and there appears to be no difference between the wall of the old spore and that of the young mycelium, the spore forming one segment in the growing mycelium, usually of a little larger diameter and shorter but often so nearly like the other segments of the mycelium that it is difficult to determine the position of the old spore. In some cases the spore seems to swell up and begin to grow by simply cutting off new segments at either end.

The spores of *Pyronema*, as shown in the present experiment, will keep their viability for nearly three years; as to how much longer they will remain good we cannot at present say. Griffiths* in his work on Fimetariaceae (Sordariaceae) found one species in which the spores kept their viability for more than three and one-half years.

The demonstration of the long viability of the spores of *Pyronema* is one more argument in favor of the introduction of this fungus into college and university courses in botany which deal with a general knowledge of the subject. The cultivation of the fungus requires no complicated technique, and the rapidity with which the plant grows would enable the student to study all of the stages from the germinating spore to the production of sex organs and mature ascocarps within a period of about ten days. Also, the asci of *Pyronema* when mounted in water illustrate very nicely the common method of spore dissemination among the ascomycetes.

Claussen† in his recent paper on the development of *Pyronema*

* Griffiths, D. The North American Sordariaceae. Mem. Torrey Club **11**: 1–134. *pl. 1–19.* 30 My 1901.

† Claussen, P. Zur Entwicklungsgeschichte der Ascomyceten, *Pyronema confluens*. Zeit. Bot. **4**: 1–80. *pl. 1–6.* 1902.

states: "Es wirt angegeben dass *Pyronema* auf Brandstellen häufig vorkomme. Häufig kann aber wohl der Pilz nicht sein, da ich ihn bisher nur ein einziges Mal—bei Eberswalde—im Freien fand. So oft ich sonst sowohl bei Freiburg wie bei Berlin solche Stellen absuchte, hatte ich keinen Erfolg."

While nothing can be said here as to the occurrence of the fungus in Europe, the fact remains that it is fairly common in America so far as our knowledge goes. Of course its occurrence in nature depends upon the presence of recently burned areas accompanied by a reasonable amount of precipitation. Given these conditions, and the fungus is common. It has been collected by the writer in Indiana, Iowa, New York, and North Dakota and has been frequently reported by collectors from other states.

If it should happen that the fungus is not common in a given locality, or as is more likely to be the case, has never been recognized, it has been shown in previous papers that the fungus is easily cultivated in the laboratory; and now having proved the long viability of the spores which enables the plant to be carried over for an indefinite length of time in the laboratory, there is no longer any reason for considering *Pyronema* an uncommon fungus. If the fungus is worth knowing from a morphological point of view it is also worth seeing.

DIRECTIONS FOR CULTIVATION AND PRESERVATION OF THE SPORES

Heat good rich, unfertilized, garden soil by placing it in pots or other receptacle. The heating can be accomplished by steam or dry heat in an autoclave or sterilizing oven. If dry heat is used run the temperature up to 150°–170° C. If neither autoclave nor sterilizing oven is available, bake in an ordinary oven for an hour or more at ordinary baking temperature. Cool and water with tap water. Plant the spores and place the pot under a bell jar. Growth of mycelium should be abundant in two or three days at room temperature; sex organs should appear in about a week and mature ascocarps a few days later.

When through with the study of plants, scrape off the old ascocarps together with a little dirt, place them in an envelope and keep dry until they are desired for study the next year, then prepare substratum and plant as before.

NEW YORK BOTANICAL GARDEN.

Explanation of plate 4

Pyronema omphalodes

1. Normal ungerminated spore.
2. Spores slightly swollen and apparently about to germinate.
3–7. Stages in the germination of spores on the third morning after planting.
8. Young ascogonia.
9–10. Ascogonia and antheridia, side and end view.
11. Mature ascus.
12. Ascus showing dissemination of spores.
13. Anastomosing mycelium.

All figures are drawn with the camera lucida; 1–7 and 13 show stages in the developing spores collected in the spring of 1909 and germinated January 1912, as they appeared on the third morning after planting.

The ferns and flowering plants of Nantucket—IX

EUGENE P. BICKNELL

CAESALPINIACEAE

CASSIA CHAMAECHRISTA L.

Sandy tracts and roadsides east of the town beyond the Creeks, extending locally as far as Quaise; also south of the town on the road to Surfside. Remaining in flower late in September. Usually undersized, often even less than 4 cm. high, with flowers only 1 cm. long and leaves 5 mm. in length, their minute leaflets reduced to three or four pairs.

Note.—The honey locust (*Gleditsia triacanthos* L.) is sparingly spontaneous about a row of rather large trees bordering the Wauwinet road at Eatfire.

PAPILIONACEAE

BAPTISIA TINCTORIA (L.) R. Br.

Scattered widely over the plains and moorland, often forming open groups, but nowhere thickly massed in extensive growths as on Long Island. On June 3, 1909, the most advanced plants were about one foot high; a precocious flower June 17, 1908.

ULEX EUROPAEUS L.

Mrs. Owen has told us (Cat. p. 22) that the furze or gorse was introduced on Nantucket by John O'Connell about the year 1860, and that at the time she wrote, in 1888, it was still growing on his farm near Hummock Pond, where it had spread both within the fence and along the road on the outside. Today the O'Connell farm belongs wholly to the past and little evidence remains of the enterprise of the pioneer who there once gave cultivation to the land. Not even the remains of any building mark the wild surroundings, and the road and old fence of which Mrs. Owen has spoken may be traced only by those who know where to look among the growth of pines and shrubbery which has all but completed its work of obliteration. Where the labor of the

early settler has left scarce a vestige to tell its tale, the gorse and the Scotch broom bear their witness to the human sentiment which here had its dwelling place in days now over half a century gone. At this spot, on June 6, 1909, the broom, almost dazzling in its wealth of bloom, everywhere spread its golden masses along the dark background of the pines and with a glow like sunshine lighted up the recesses among the shrubs and trees. Blooming with it in scarcely paler brightness, but nowhere far strayed from the course of the vanished roadway, the gorse, in spiny clumps and formidable thickets was also in strong possession of its conquered ground. Its greatest continuous growth exceeded one hundred and ten paces in longer extent and twenty paces in maximum transverse breadth, the stouter shrubs having reached a height of four to six feet, with stems four to six inches in circumference. It had flowered earlier than the broom, some of the blossoms having already begun to fade. In June 1911, both the gorse and broom were found to have suffered severely, probably from the long-continued drought, and much of both was either partially or wholly dead and brown.

CYTISUS SCOPARIUS (L.) Link.

Now extensively naturalized on Nantucket, the Scotch broom is steadily increasing and spreading to new localities year by year. Writing in 1888, Mrs. Owen included the species in her catalogue on the evidence of a single plant reported by Mr. J. H. Redfield as growing among the furze bushes on the O'Connell farm. At that locality in 1906 the broom was found to have spread extensively in a contest for supremacy with the young pines among which it grew, and the larger plants had attained a height of eight to ten feet and their stems a basal girth of four to six inches. In 1899, when this locality was unknown to me, the broom was observed at only three stations, east, west, and south of the town. On my next visit to the island, five years later, small clusters were seen at three places on the Wauwinet road between Shawkemo and Polpis, and an extensive growth formed a stubborn thicket along the western border of Trot's Swamp on the site of the old Barrett farm. In 1906 it had appeared here and there along an old cart-road in Polpis and was first observed on the bluff at Siasconset, extending down the steep slope from the top, where it had doubt-

less been planted. The following year new localities were noted about one mile southeast of the county fair grounds, near Almanac Pond and on the roadway through Spotsor country, new stations having become established also along the Wauwinet road. In 1908 many scattered colonies were found in the neighborhood of the long-abandoned Barrett farm. It was also seen that year for the first time near Reed Pond and east of the county fair grounds. In 1909 it had sprung up at a number of suburban localities and was first observed as far east as Squam towards Quidnet, as far southeast as the abandoned Kimball farm in the south pasture, and on the south side of the island near Miacomet Pond; it was also well established along the old south road about two miles from the town. A thriving colony in private grounds among the pines at Wauwinet had doubtless been planted there, and a considerable thicket east of Shimmo farm was so well founded that it could scarcely have been of very recent origin. In 1911 the plant was first seen on the Madequet road towards Long Pond.

As early in the season as May 30, 1909, the broom was in full flower; it was in equally conspicuous bloom on June 6, 1909, and from June 15 to 20, 1910, although on June 20, 1908, it was passing out of flower. Occasional single flowers are to be found in August and September. It fruits freely, maturing abundant seed.

On a visit to Marthas Vineyard in October, 1909, it was found that the broom had effected a lodgement on that island. A group of four bushy plants or clusters, the tallest about four and one-half feet high, grew by a thicket on the west side of Sengekontacket Pond, and a solitary plant two feet high near the shore road three miles or so north of Edgartown. In 1911 a tuft had sprung up by an old roadway near the golf links at Edgartown, and a small clump was observed on the northwestern side of the island near Lambert's Cove.

*MEDICAGO SATIVA L.

Frequent in grassy lots and in outlying fields near the town. First flowers June 18, 1908; in full flower at the middle of September 1907. Siasconset, 1886, Mr. Nickerson, fide F. G. Floyd.

MEDICAGO LUPULINA L.

Rather common, mainly along roadsides and in the more inhabited parts of the island. First flowers, May 30, 1909; in full flower at the middle of September 1907.

MELILOTUS ALBA Desv.

In 1904 this plant was found only along the railroad in the town, where it was well established; two years later it had extended in detached groups here and there along the Siasconset and Wauwinet roads and in 1908 had sprung up at several places about the town. First flowers June 18, 1908; June 23, 1910.

*MELILOTUS OFFICINALIS (L.) Lam.

First observed by me on Aug. 11, 1906, a cluster in full flower in a field near Miacomet Pond; in 1908 a solitary plant was seen below the "Cliff," and a patch south of the town; in 1910 it had appeared at another station south of the town and was found on June 25 at Sankaty Head, extending in a wide breadth of bloom down the face of the bluff. Many years before, it grew at this spot, having been found there in abundance in 1888 by Miss Elizabeth S. Kite and again, in 1891, by Mrs. Mabel P. Robinson.* It was also observed by Mr. Floyd as early as 1895 at Brant Point, where it still persists and showed its first opened flowers June 3, 1911.

TRIFOLIUM AUREUM Poll.

Common in sandy soils and grassy places. First flowers June 10, 1908; June 12, 1909; June 15, 1910; also in full flower late in September.

* For these records I am indebted to Mr. Frederick G. Floyd, who has sent me a manuscript list of additions to Mrs. Owen's Catalogue, which he has had in preparation since 1905. My own explorations on Nantucket had been carried on in the belief that since the publication of Mrs. Owen's list the island had remained an almost neglected botanical field. How mistaken was this belief is disclosed by Mr. Floyd's manuscript, which shows that the island has continuously inspired the active botanical interest of many collectors, one or more of whom have made new discoveries in its flora almost from year to year. And not less an occasion of surprise to me is this, that in the many absorbing botanical days I have myself passed exploring this garden of the sea it has never been my fortune to encounter a kindred spirit, neither a botanist nor an explorer in any branch of nature study.

It appears from Mr. Floyd's notes that some of my own supposed discoveries were earlier made by others, and it will be a pleasure here to make record of all such additions to the island's flora that have received Mr. Floyd's or other adequate verification. To Mr. Floyd I extend my appreciative acknowledgments for his generous contribution to the greater completeness of the present paper.

TRIFOLIUM PROCUMBENS L.

Gravelly and sandy fields and dry grassy slopes, mainly in the more settled parts of the island, usually growing in close beds or smaller isolated patches. Very common in the neighborhood of the town and from Reed Pond to the county fair grounds, extending as far east as Shawkemo; common in Madequet and about Siasconset. First flowers May 30, 1909; just in flower June 7, 1911; blooming abundantly during June. Some flowers Sept. 16, 1907.

*TRIFOLIUM DUBIUM Sibth.

Roadsides, fields, and grassy places. Abundant throughout the north side of the island from Madequet to Squam; abundant also in the southwest quarter and about Siasconset. Apparently beginning to bloom rather earlier than *T. procumbens* and having a briefer flowering period. First flowers May 30, 1909; much of it past flowering June 18, 1908, and June 26, 1910. Mr. Floyd's notes contain a reference to this species on Nantucket as far back as 1889, when it was collected by Miss Elizabeth S. Kite.

*TRIFOLIUM INCARNATUM L.

Occasional in old fields, persisting where it has been sown, but apparently never becoming permanently established. Siasconset 1899. In full flower May 30, 1909, and late in September. North Beach Street—meadow—evidently introduced in grass seed, 1895, F. G. Floyd; yard in town, 1896, Mrs. Mabel P. Robinson, fide F. G. Floyd.

TRIFOLIUM ARVENSE L.

Abundant in dry sterile soils. When almost in flower it often remains a long time without coming actually into bloom. Appearing to be in flower June 15, 1910, but no flowers fully opened until June 27. In September many young plants often come into bloom among others that had completely dried up long before.

TRIFOLIUM PRATENSE L.

Very common. In early June it is conspicuous from its luxuriance and profuse bloom in low-lying grassy lots in the town. First flowers May 30, 1909.

TRIFOLIUM HYBRIDUM L.

Common in and about the town; less frequent at more distant

points. Comes into flower later than either *T. repens* or *T. pratense;* first flowers June 3, 1911, June 15, 1910; not blooming freely until June 20, 1908; remaining in flower through September.

TRIFOLIUM REPENS L.

Very common either in dry or moist soils and varying greatly both in size and habit. First flowers June 2, 1909; in full flower June 15, 1910; blooming through September.

CRACCA VIRGINIANA L.

Abundant on the plains west of the middle of the island and towards the south shore; Great Neck; north of Siasconset; nowhere seen on the northern half of the island. Plants just appearing May 31, 1909; leaves beginning to unfold June 9, 1908; first flowers June 17, 1908; abundant fruit at the middle of September, 1907.

*ROBINIA PSEUDACACIA L.

Well established along the old south road, and spontaneous at several places on the outskirts of the town; sparingly at the Miacomet pines. In 1889 a thicket or close growth of young trees had become established in open ground north of the town; this has since developed into rather a conspicuous grove, the larger trees having a height of not less than twenty feet and a basal girth of 17 inches. First flowers June 15, 1910, June 16, 1911; still in full bloom June 27, 1910.

*ROBINIA VISCOSA Vent.

Occasional by roadsides near the town and at Siasconset. Has spread little if at all since 1889, when it was first observed. First flowers June 22, 1910.

CORONILLA VARIA L.

Along a neglected roadside and in a waste yard in the town, where it was first observed in 1906; a luxuriant growth in full bloom in a grassy field border south of the town June 18, 1908; at Siasconset along a roadside fence (1906) and on the bluff (1908). Not yet in flower June 17, 1911.

MEIBOMIA OBTUSA (Muhl.) Vail.

Rather common on the eastern side of the island, especially in Squam and in the region about Saul's Hills; occasional on the plains towards the south shore but not seen west of Hummock

Pond; on the north side of the island not seen west of Shawkemo. In full flower and abundant fruit Sept. 1, 1904; last flowers Sept. 11, 1899.

Except on Nantucket I have not noticed that this plant may relax from its erect or stiffly ascending habit. Here it is frequently quite prostrate, the slenderly elongated stems and branches of the panicle proceeding almost in the trailing manner of a *Lespedeza* among the grass and low plants of the dry open places where it grows. These prostrate forms are more slender and less pubescent than normal suberect states of the plant and have less numerous and crowded leaves with thinner leaflets.

*MEIBOMIA RIGIDA (Ell.) Kuntze.

Growing sparingly on a dry open slope in Squam, Sept. 21, 1907, and bearing abundant fruit; rather a small form of the plant becoming 6 dm. high, the leaflets 3–4 cm. long by 1.5 cm. wide.

*MEIBOMIA CANADENSIS (L.) Kuntze.

Mrs. Nellie F. Flynn has sent me a flowering specimen of this tick trefoil, which was collected on Nantucket Aug. 13, 1904, by Mrs. Eleanor W. Morgan, no locality being given.

*MEIBOMIA SESSILIFOLIA (Torr.) Kuntze.

In the herbarium of the Nantucket Maria Mitchell Association I found a sheet of this species, which had been collected on Nantucket by Mrs. Nellie F. Flynn Aug. 23, 1901. In regard to this specimen Mrs. Flynn has written me that she collected it "by a roadside just west of the farm house near and west of Nobadeer Pond," where it grew very sparingly.

LESPEDEZA PROCUMBENS Michx.

Locally common in open pine scrub and on the plains and commons, occurring in all quarters of the island. Stems a few inches long June 7, 1909; small flower buds Aug. 11, 1906; first flowers Aug. 29, 1904; in full flower Sept. 1 to 15.

On Nantucket this species is subject to much variation in degree of pubescence and in other characters. Two varieties are especially to be noted, one whitened with a dense velvety pubescence, the other having a looser pubescence of shorter, less spreading hairs and flowers tending to be smaller and of somewhat different proportions, the petals narrower, the wings often sur-

passing the keel, the standard paler and less distinctly lineate; also, the pods are commonly smaller and more orbicular.

*LESPEDEZA BRITTONII Bicknell.

Found in much the same situations as the preceding and sometimes growing with it but less widely spread. It is often quite prostrate, and on the open plains towards the south shore of the island forms close mats three or four feet in diameter of radiating and flatly interlaced stems and branches, which in August and September are loaded with the flowering racemes. First flowers Aug. 11, 1906; in full flower Aug. 29, 1904, Sept. 15–23, 1907. Often develops an unusual degree of dense cinereous pubescence.

*LESPEDEZA NUTTALLII Darl.

Met with at only two stations: between Siasconset and Tom Never's Pond, Aug. 31, 1904, the flowers rather pale pinkish white with the standard medially purple-lineate; and near the railroad about the fifth mile, Sept. 2, 1904, the flowers deeply purple-tinged. At both stations the plants were rather low, 3–6 dm. high, with unusually contracted inflorescence, which appeared capitate by reason of the short, densely floriferous racemes massed together at the end of the stem. The plants were perfectly healthy, but their repressed inflorescence seemed to announce that some factor of their environment had been unfavorable to their freest development.

*LESPEDEZA STUVEI Nutt.

A small group of plants in full flower Aug. 31, 1904, near Siasconset towards Tom Never's Pond; two stations in Saul's Hills, Sept. 19, 1907, the plants well fruited and with some late flowers. Plants 2–3 dm. high were observed in Saul's Hills June 8, 1908.

*LESPEDEZA VIRGINICA (L.) Britton.

Occasional, and locally common on the eastern half of the island, especially along the state road. The Nantucket plant is often notably pale in color from an investiture of appressed sericeous pubescence densely clothing the younger parts and the lower surface of the leaves, and to a less extent the upper surface also. Flower buds barely discernible Aug. 13, 1906; in full flower Sept. 15, 1907; last flowers Sept. 12, 1899.

LESPEDEZA FRUTESCENS (L.) Britton.

Infrequent. Bank near the Creeks; near Tom Never's Pond and westward on the moors; Shawkemo. On the western side of the island it was met with only at one station, on the plains towards Hummock Pond. In full flower Aug. 31, 1904, Sept. 4, 1899, abundant fruit and some late flowers; no flowers remaining Sept. 17, 1907.

Probably the *Lespedeza violacea* of Mrs. Owen's list.

LESPEDEZA HIRTA (L.) Hornem.

Not uncommon but somewhat local and not seen at all in the western half of the island. Frequent over the south pasture and on the moorland toward Siasconset; Shawkemo; Saul's Hills; Polpis; Squam. Just in flower Aug. 13, 1906; in full flower Sept. 13, 1907.

On the open moorland a form occurs—it grows also in the pine barrens of Long Island—in which the crowded leaves are densely villous-tomentose beneath and almost felted on the upper surface with a densely appressed soft pubescence; their petioles are commonly shorter than in the usual form of the plant and the leaflets elliptic to obovate-oblong and suborbicular; the pubescence is often notably ferrugineous. This plant is undoubtedly a well characterized variety, yet if it were to receive a name as such, consistency would require that names be given to other only less markedly set apart forms of this bush clover and of all our other species as well.

LESPEDEZA BICKNELLII House, Torreya **5**: 167. 1905.

L. velutina Bicknell, Torreya **1**: 102. S 1901. Not *Lespedeza velutina* Dunn; Hooker, Icones Pl. IV. **7**: *pl. 2700.* F 1901. A native of China.

The only abundant and generally distributed bush clover of Nantucket, found everywhere in dry open places, even growing in white sand among the beach grass along the shores. Although sometimes erect or ascending to a height of one or two feet, it is more often nearly or quite prostrate. Even the early shoots are often declined and in June are to be seen radiately decumbent or prostrate around dead suberect stems of the preceding year. On Marthas Vineyard this bush clover is also the prevailing species, but it is there mostly erect, although on the plains some-

times becoming quite prostrate. On Chappaquiddick Island, where the vegetation in general is more like that of Nantucket than on Marthas Vineyard proper, no plant of this species was found that showed any prostrate tendency.

On Nantucket, like several other Lespedezas, this species develops as unusual degree of pubescence, the stems becoming velvety-cinereous, the leaflets conspicuously whitened and almost felted on both surfaces with a velutinous canescent or appressed silky indument. Stems a few inches long June 2, 1909; first flowers Aug. 11, 1906; in full flower Aug. 28, 1904; no flowers left Sept. 2, 1907.

Nothing was seen of *L. capitata* Michx., although it may be expected to occur since it was found at one station on Marthas Vineyard. The name appears in Mrs. Owen's catalogue but of course refers to the allied species, which was not recognized until many years later.

*VICIA VILLOSA Roth.

Occurs sparingly at one locality in Quaise, where it is found running through the grass about an isolated and long-abandoned dwelling. First flowers June 15, 1911; in full flower Aug. 16, 1906, Sept. 17, 1907.

*VICIA TETRASPERMA (L.) Moench.

Not observed until 1909, when it was found not far from the old mill along a roadside bank and intricately entangled over many rods of an adjoining field. The next year it was seen at the foot of the "Cliff" and in quantity by a roadside southwest of the town. Near Union Street, 1904, Mrs. Nellie F. Flynn; near Orange Street, 1905, J. R. Churchill, fide F. G. Floyd. Just in flower June 15, 1910; in full flower June 13, 1909, June 26, 1910. Corolla larger than in *V. hirsuta*, purplish and pinkish tinged, the standard purple-lineate.

*VICIA HIRSUTA (L.) Koch.

One station north of the town, where there is a tangled growth in a hollow of a sloping sandy field; near the docks, 1895, Mrs. Nellie F. Flynn, fide F. G..Floyd. Not yet any flower buds May 30, 1909; first flowers June 12, 1909; June 15, 1910; June 15, 1911. Corolla smaller than in *V. tetrasperma*, bluish and white, the standard without darker lines.

VICIA SATIVA L.

Abundant in the town and suburbs, running rife amid the grass in fields and meadows and along roadsides In full flower May 30, 1909; June 7, 1908. Appears to have increased remarkably within very recent years. Mrs. Owen mentions it as occasional in dooryards and old fields.

*VICIA ANGUSTIFOLIA Roth.

Now very common but not noticed before 1907, when it was seen at two stations in the town and in an old field a mile out; the next year it was found to be frequent in the general town region and was observed at Monomoy, Shawkemo, Madequet, and in the southwest quarter. In full flower June 7, 1908; June 15, 1910. Like the preceding, this vetch seems to have increased greatly in recent years. The two are often found growing together and appear to hybridize, since examples are frequent which it is scarcely possible to assign conclusively to one or to the other.

LATHYRUS PILOSUS Cham.

Borders of brackish or fresh-water meadows along the harbor, locally common from the Creeks to Pocomo; Squam Pond; Sachacha Pond; Little Neck. Under the name *Lathyrus palustris* L., Mrs. Owen has recorded that it was found at Hummock Pond by Mr. J. H. Redfield. First flowers May 30, 1909; June 7, 1911; a few flowers remaining Aug. 28, 1904. Stems, leaves, calyces, and even the tendrils more or less pubescent, the younger parts pilose-canescent; stems commonly broadly winged, at least above; leaflets 2 or 3 pairs (rarely 1 pair or 4 pairs), narrowly linear to lanceolate or narrowly oblong, 2.5–7 cm. long; peduncles 2–4-flowered, the flowers 1.5–2 cm. long, bright crimson changing to clear deep blue.

LATHYRUS MARITIMUS (L.) Bigel.

Common along the coastal sands, often extending back among the dunes; along the top of the bluff on the north shore; abundant at the western end of the island. First flowers June 7, 1909; just in full flower June 7, 1908; occasional flowers in September. At one locality near the bathing beach, in June 1910, many plants bore only pale flowers, white with lavender standard. Varies from glabrous to densely short-pubescent.

*LATHYRUS TUBEROSUS L.

In Quaise, making a luxuriant tangle among the grass along and near an old fence. Not yet with any signs of flower buds June 9, 1911.

APIOS APIOS (L.) MacM.

Rather common in low grounds and on the borders of swamps. In full flower at the middle of August, 1906; no flowers seen in September.

FALCATA PITCHERI (T. & G.) Kuntze.

Sparingly in Watt's Run bog at the border of a wet thicket, Sept. 17, 1907, well fruited and with some faded flowers remaining. Stems retrorsely rusty-villous; larger leaflets oblong-ovate, 7 cm. long by 4 cm. wide, appressed-hairy on both surfaces; calyx 7 mm. long; pod 3 cm. long or longer, the margins retrorsely hispid-villous; sides of the mature valves glabrous.

Referred to *F. Pitcheri* with reservations pending a more critical study of our hog peanuts than seems yet to have been attempted. The indications appear to point to more than two species in our flora. The Nantucket plant is scarcely identical with typical *F. Pitcheri*, ordinarily an inhabitant of low open thickets, yet it is certainly closer to that species than to *F. monoica*, a smaller and more delicate woodland plant. The latter was not seen on Nantucket, but it is locally common on Marthas Vineyard in the hilly woodland on the western side of that island. It is mentioned in Mrs. Owen's catalogue but the exact plant intended cannot now be known.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1910-1912)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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